UPLINK CHANNEL POWER CONTROL IMPROVEMENT IN DS-CDMA SYSTEM USING CHANNEL PREDICTIONS

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For my father

Who had major role to support me before he passed away.

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ABSTRACT

In cellular systems all Mobile's Station (MS) signals should arrive to Base Station (BS) at equal power, if not the weaker one will be blocked and the strong signals will interference with each other. The research areas include coding and improving power control for uplink channel schemes in cellular systems. Commonly the uplink channel power control schemes utilizes Signal to Interference Ratio (SIR) to design a Power Control Command (PCC) to adjust the transmit power of the mobile station in cellular systems.

Conventional SIR based uplink channel power control schemes updates the transmitting power based on the current channel state, in the fact the state of channel will be changed when the transmission is made; the channel is already in its next state. The state is different from previous one. That causes the SIR to drop or rise drastically and lead to Near-Far effect interference resulting in power escalation and making the DS-CDMA system go unstable.

To overcome these problems, a new approach method has been developed, based on linear quadratic Gaussian (LQG) control and Extended Kalman filter for channel prediction, this method dependent on the channel state instead of the current. Using the proposed method the next state of uplink channel can be predicted and update the power accordingly. This will give us a more stable SIR behavior and leads to stable DS-CDMA system.

The simulation of this research is performed using Matlab to show the result of building a DS-CDMA system link with existing SIR based uplink channel power control schemes, implementing the predictive approach for uplink channel power control achieved the signal to interference ratio (SIR) as close as possible to the predefine level in order to maximize a DS-CDMA systems capacity and performance. That is clearly shown in the results when compared with the conventional methods.

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LIST OF ABBREVIATIONS

SIR	-	Signal to Interference Ratio
PCC	-	Power Control Command
DS-CDMA	-	Direct Spread-Code Division Multiple Access
MT	-	Mobile Terminal
BS	-	Base Station
MS	-	Mobile Station
LQG	-	Linear Quadratic Gaussian
TDMA	-	Time Division Multiple Access
GSM	-	Global System for Mobile
PDC	-	Personal Digital Cellular
FDMA	-	Frequency Division Multiple Access
ISDN	-	Integrated Services Digital Network
DSSS	-	Direct Sequence Spread Spectrum
FHSS	-	Frequency Hopping Spread Spectrum
PN	-	Pseudo-Noise
S/I or SIR	-	Signal-To-Interference
PC	-	Power Control
CLPC	-	Closed Loop Power Control
MUX	-	Multiplexer
DEMUX	-	Demultiplexer
PCM	-	Pulse Code Modulation
LQE	-	Linear_Quadratic Estimator
LQR	-	Linear_Quadratic Regulator
KF	-	Kalman Filter
EKF	-	Extended Kalman Filter
d B	-	decibel
MHz	-	Mega Hertz
GHz	-	Giga Hertz

ms	-	meli second
MMSE	-	Minimum Mean Squared Error
AR	-	Auto Regressive
GUI	-	Graphical User Interfaces

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CHAPTER I

INTRODUCTION

1.1 Overview

Power is one of the basic factors that must be taken into account when designing a communication system. By reducing it as much as possible to achieve a successful communications system economically.

The research areas include coding and improving uplink channel power control schemes in mobile system. Commonly the power control schemes uses a Signal to Interference Ratio (SIR) to design a Power Control Command (PCC) to adjust the transmit power of the mobile station in mobile system.

Mobile communication systems based on DS-CDMA as the controlling air interface solution in mobile telecommunications plane (Pasad, 1998). DS-CDMA is an attracting technique, since it allows high capacity and supports variable bit-rate user transmissions. New aspects need to be carefully taken into consideration when a DS-CDMA air interface is designed. In particular, equal power levels must be received at the base station (BS) from different Mobile Terminals (MTs) in a cell (uplink), if not the weaker one will be blocked and the strong signals will interfere with each other and making the system unstable.

In conventional methods, each transmitted signal from Mobile Station (MS) will be affected by different propagation such as path loss like (reflection, diffraction and absorption) that appear in reverence link (mobiles to base station).

These channel changes may cause the SIR to drop or rise drastically and lead to uncontrollable Near-end-Far-end interference resulting in power escalation and making the system unstable. This critical problem is within the power control of uplink channel where orthogonal spreading codes cannot be used and channel variations and distances cause severe interference between users. Without a proper power control scheme the communication system would not be able to handle as many users.

To overcome power escalation and improve the recovery from deep fading (deviation of the attenuation affecting a signal over certain propagation media) a new approach power control method has been developed. Based on linear Quadratic Gaussian (LQG) control and Extended Kalman filter for uplink channel prediction this method designs the PCC based on the coming channel state instead of the current. This research will explain the components of this method, about how Extended Kalman filter works to predict the status for the channel and apply in Matlab to see the results obtained and the difference between the results of a new approach method with the conventional methods.

1.2 Problem Statements

Today wireless communications and especially the mobile telecommunications systems are based on Direct Spread Code Division Multiple Access (DS-CDMA) technique. In a DS-CDMA communication system, several users that transmit simultaneously share the same radio bandwidth. In order to maintain the quality of a connection, the signal-to-interference ratio at the receiver (base station) should be kept over a required value. Therefore, transmitter power includes a major controllable recourse for the improvement of the user's radio link performance (Bambos, 1998) (Ariyavisitakul, 1994).

The problem in transmission power on the uplink channel for a DS-CDMA system is increased because slow SIR recovery due to path loss. All MS's signals will be affected by different propagation from wireless channel and signal power may drop, that lead to severe interference from other users and causes low capacity for DS-CDMA system.

These users will in their turn start compensating by increasing power, may lead to power escalation or positive feedback, which may have whole system go unstable. It is known that any communication system in order to be successful, the power consumption must be as low as possible. Therefore, this research work aims to reduce the power consumption to the minimum.

Having a new approach power control method based on Linear Quadratic Gaussian (LQG) control and Extended Kalman filter for channel prediction, this method designs the PCC based on coming channel state instead of the current. By using the proposed method the next states of the channel can be predicted and update the power accordingly.

This method explains how the Extended Kalman filter work to the predicted state of channel. The results using Matlab are shown to see the signals through the transmission and compared to the results before and after using this method. The result shows a more stable SIR behaviour and, more importantly, faster SIR recovery from channel variations. This will result in a more stable DS-CDMA system.

1.3 Project Objectives

The objectives of this research are:

i. To Simulate a DS-CDMA system based on a new approach. method by using Matlab.
ii. Reduce the power consumption.
iii. To get faster SIR recovery.
iv. To avoid interference between users.
v. To maximize the capacity and better performance for DS-CDMA system.
vi. To achieve stable DS-CDMA system.

This requires an optimal power control scheme. A power control scheme based on LQG control and Extended Kalman filter to predict the channel were suggested. This method was tested by building a simulated DS-CDMA link with existing SIR based uplink power control schemes, implementing the predictive approach for power control and compares it to the conventional method. Depending on the results from the comparison it may be concluded that the suggested method of power control performs better.

1.4 Project Scopes

The scopes of this project have various strategies such as:

i. Use of DS-CDMA in the system.

All users send the information simultaneously on the same bandwidth. Because the DS-CDMA system is inherently interference limited, it is important to keep the transmission power of each mobile user as low as possible.

ii. Utilization of power control.

This is to control the transmitted power from mobile user to base station that mean make SIR work in desired value. This process has three loops: open loop, outer loop and close loop. This research is interested to deal with SIR which based on closed loop that has three steps: fixed step size, quantized step size and ideal step size.

iii. Choose of an Extended Kalman filter to predict the state of channel.

Extended Kalman filter is known as non-linear quadratic estimation. It is used to estimate a signal in a presence of Gaussian noises. Power control system is designed by adding an Extended Kalman filter to achieve a perfect performance.

iv. Simulation and verification.

This method is simulated and verified using Matlab. A significant difference between the previous methods and a new approach method was observed.

CHAPTER II

LITERATURE REVIEW

2.1 History of wireless communication

The history of wireless communications began in 1886 when H. Hertz generated and, thus, proved the presence of J. C. Maxwell's theoretically predicted electromagnetic waves. In the following year G.Marconi showed the possible of wireless communications, as clearly documented by the words delivered before the Royal Institution in 1897 from the Technical Director of the British Post Office, who supported G. Marconi:

"It is curious that hills and apparent obstructions fail to obstruct... Weather seems to have no influence; rain, fogs, snow and wind, avail nothing... The distance to which signals have been sent is remarkable. On Salisbury Plain Mr. Marconi covered a distance of four miles. In the Bristol Channel this has been extended to over eight miles and we have by no means reached the limit. It is interesting to read the surmises of others. Half a mile was the wildest dream."

In 1901 G. Marconi established a radio connection over the Atlantic. Sequence results, research and development led to use one of the most widely applications in the wireless communication system, that of radio broadcasting. Using this medium, G. Marconi in 1937, said in a radio message:

“Radio broadcasting, however, despite the great importance reached and the still unexplored fields open to investigation, is not, in my opinion, the most significant application of modern Communications, because it is a one way communication only. Greater importance is related, in my opinion, to the possibility offered by radio of exchanging communications anywhere the correspondents are located, in the middle of the ocean, in the ice pack in the pole, in the desert plains or over the clouds in an airplane."

These words should prove to be true and one hundred years after G. Marconi's first experiments, the market of wireless mobile communications with duplex transmission is one of the fastest expanding of the world. The establishment for a widespread of wireless mobile communications was laid with the standardization of the first generation cellular mobile radio systems in the 1980s. The origins of digital communications go back to the work of S. Morse in 1837, demonstrating an electrical telegraphy system. The so-called Morse code represents the letters of the alphabet by sequences of dots and dashes and was the major of modern variable-length source coding.

The rapid development in the area of micro electronics with a continuous increase in device density of integrated circuits and the development of low-rate digital speech coding techniques made completely digital second generation cellular mobile radio systems created. Various second generation cellular systems were developed in the 1990s. Most of these systems use time Division Multiple Access (TDMA), such as the Global System for Mobile Communications (GSM) and the Digital Cellular System 1800 (DCS1800) in Europe, the Interim Standard (IS-54) in the USA, and the Personal Digital Cellular (PDC) system in Japan. With TDMA, the time axis is subdivided into different non-overlapping time slots where each user has time slot; TDMA is combined with Frequency Division Multiple Access (FDMA) to reduce the hardware complexity of an otherwise extremely broadband system and to increase the flexibility of the system.

Parallel to the TDMA based second generation standards, the IS-95 was developed in the USA, used Code Division Multiple Access (CDMA) with direct sequence (DS) spectrum spreading, combined with FDMA. The origins of CDMA go back to the beginnings of spread spectrum communications in the first half of the 20st century. Primary applications of spread spectrum communications put in the development of secure digital-communication systems for military use. Since the second half of the 21st century, spread spectrum communications became of great interest also for commercial applications, including mobile multi-user Communications.

The spectrum spreading is achieved by using a spreading code that is independent of the message and is known to the receiver. The receiver uses a synchronized replica of the spreading code to despread the received signal allowing recovery of the message. The operation of the spread spectrum technique to enable multiple users a simultaneous access to the channel is called CDMA.

The increasing interest for CDMA digital mobile-communication systems has lead of late to the consideration of optimizing the power control. As the CDMA systems are originally interference limited, it is importance to keep the transmission power of each mobile user as low as possible (Gilhousen et al., 1991).

This is critical in the uplink transmission (from mobile to base station), where all the mobile units need to be controlled by the base station to keep the received power level from each mobile unit constant in the average. The need for power control has been widely studied, and the capacity of a CDMA system is found to greatly depend on the power control function (Tongus & Wang, 1994).

Power control in cellular networks has been widely studied since the late 1980s as an important mechanism to control Signal-to-Interference Ratio (SIR). Specifically, in the past system designer's choices where driven by their knowledge, designed the power control planners use the signal to interference ratio (SIR) to design a Power Control Command (PCC), to set the power sent from mobile stations to base station. However, this design gave a clear problem that is the slow SIR recovery due to the factors affecting on the signal during propagation inside the channel. Such as non linearity, fading, and interference from other users. These designees base the PCC on the current channel state when in fact the channel state will be changed when transmission occurs. That led to make the SIR drop or rise drastically and also lead to Near-Far-effect interference. In turn will increase the power sent by mobiles to overcome this problem that produces power escalation and making the system unstable. Solution for the escalation power and unstable system should be selected by improving the sending power from mobile stations to base station by taking into account the basic features of channel. This research shows an important issue to improving the uplink power control channel for DS-CDMA system. Here focusing on the uplink prediction channel and representation how the prediction can be done by using linear Quadratic Gaussian (LQG) control and Extended Kalman filter to get a stable DS-CDMA system.

2.2 Code Division Multiple Access system (CDMA)

In CDMA system each user uses a different code to modulate their signal. Choosing the codes used to modulate the signal is very important in the performance of CDMA systems. The best performance will occur when there is good separation between the signal of a desired user and the signals of other users.

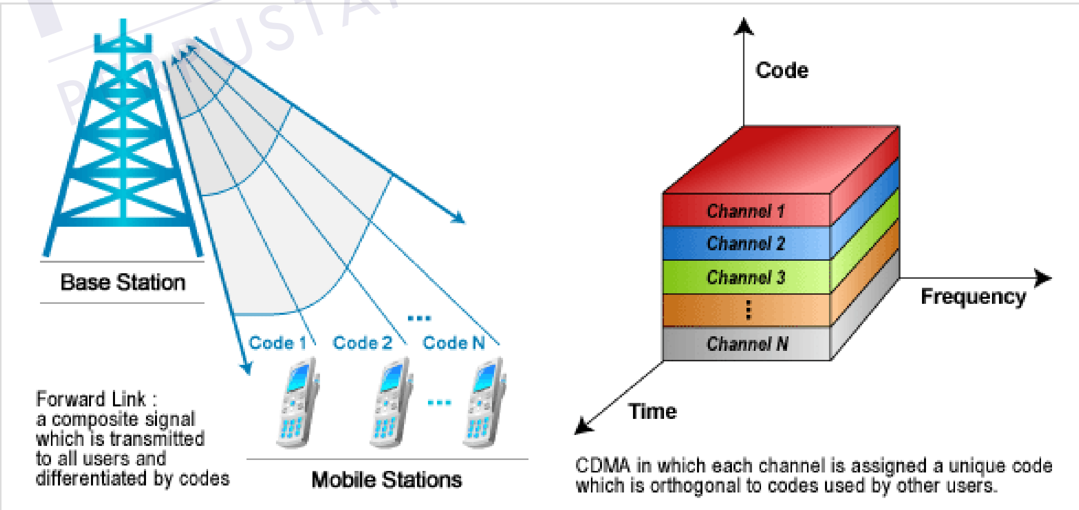

Figure 2.1: The CDMA system.

In fact, CDMA, TDMA and FDMA have exactly the same spectral efficiency but practically, each has its own challenges, power control in the case of CDMA, timing in the case of TDMA, and frequency generation/filtering in the case of FDMA.

TDMA systems must carefully synchronize the transmission times of all the users to ensure that they are received in the correct time slot and do not cause interference. Since this cannot be perfectly controlled in a mobile environment, each time slot must have a guard-time, which reduces the probability that users will interfere, but decreases the spectral efficiency. Similarly, FDMA systems must use a guard-band between adjacent channels. The guard-bands will reduce the probability that adjacent channels will interfere, but decrease the utilization of the spectrum.

With these considerations, CDMA has been selected as the best system used in wireless communication. This system has several advantages:

- High purity in the transfer of voice and data.
- Safer with effective protection against leakage illegal for calls or data.
- Number of unsuccessful calls less the equivalent of 15 times for traditional mobile.
- Telephones are working with very low frequency signals, which make use of safer on the health of people with consideration to radiation as it provides battery consumption.
- Effective use of frequency waves (frequency band).
- Does not need to frequency planning.
- The ease and flexibility in developing the system upgraded and updated.

These features gave the motivation to choose the CDMA system. There are two types of CDMA systems deployed in practice:

- Direct Sequence Spread Spectrum (DSSS).
- Frequency Hopping Spread Spectrum (FHSS).

Frequency Hopping Spread Spectrum (FHSS) or Frequency Hopping Code Division Multiple Access (FH-CDMA), in which a broad slice of the bandwidth spectrum is divided into many possible broadcast frequencies. In general, frequency-hopping devices use less power and are cheaper, but the performance of DS-CDMA systems is usually better and more reliable.

2.3 Direct Sequence Code Division Multiple Access (DS-CDMA)

Direct sequence spread spectrum, also known as Direct Sequence Code Division Multiple Access (DS-CDMA) is one of two processes to spread spectrum modulation for digital signal transmission over the airwaves. In direct sequence spread spectrum, the stream of information to be transmitted is divided into codes every user have special code.

A data signal at the point of transmission is combined with a higher data-rate bit sequence (also known as a chipping code) that divides the data according to a spreading ratio. The redundant chipping code helps the signal resist interference and also enables the original data to be recovered if data bits are damaged during transmission.

Spread spectrum first was developed for use by the military because it uses wideband signals that are difficult to detect and that resist attempts at jamming. In recent years, researchers have turned their attention to applying spread spectrum processes for commercial purposes, especially in local area wireless networks.

2.3.1 Features of DS-CDMA System

Direct Sequence (DS) Code Division Multiple Access (CDMA) is a promising technology for wireless environments with multiple simultaneous transmissions because of several features:

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